SEQUENTIAL FAULTING HISTORY OF VALLES MARINERIS, MARS. A. N. Fori and R. A. Schultz, Geomechanics-Rock Fracture Group, Department of Geological Sciences, Mackay School of Mines, University of Nevada, Reno NV 89557-0138 (afori@mines.unr.edu).

Summary: The location and orientation of the shallow faults that characterize the plateau in the Valles Marineris region of Mars are investigated to derive the sequential extensional tectonic history of the region. The stress trajectories developed for the Valley suggest two episodes (northwesterly and northeasterly) of faulting occurred prior to the greatest extensional direction (north-south) that most likely created the Valley proper and surrounding parallel grabens. The results independently confirm the relatively young formation of the Valley.

Introduction and Previous Work: Stress and tectonics across Mars on a planetary and regional scale is explored in the 1992 book "Mars" in the chapter by Banerdt, Golombek, and Tanaka [1]. The importance of Tharsis is emphasized, as are the mechanics of lithospheric deformation. Tanaka and co-workers [2] model the stress and structural history of the Tharsis area. Strain at depth is reconciliated from studying fractures at and inferring those below the planet's surface. From this, the structural and geologic history of the planet is integrated into the previously developed structural and geologic history of the planet as a whole. Mège [3] determined the amount of crustal stretching in Valles Marineris, the uniquely large (~4000 km long, ~10 km deep) extensional feature extending radially from Tharsis.

The purpose of this study is to determine the basis for the existence and orientation of the shallow faults that characterize the plateau in the Valles Marineris region of Mars and to derive the sequential extensional tectonic history of the region. Using cross-cutting relationships, and local geology and topography, stress trajectories are developed that orient and relatively time the sources of stress that caused the deformation. The conclusions derived herein are independent and consistent from previously conducted stress model results.

Methods and Results: Viking orbiter data are used to delineate ~2000 structures (normal faults and grabens) located on the plateau surrounding Valles Marineris. Cross-cutting relationships are clearly visible in many locations.

Figure 1 was created from the cross-cutting relationships of plateau grabens. The numbered stress trajectories ("1" is the oldest) illustrate the sequential faulting history of the Valles Marineris area. There are five main areas, or domains, of faulting. The lack of cross-cutting relationships cannot be determined uniquely. Within each of the five areas, age relationships are clear. For example, in Area #1, which appears to have experienced the most episodes of faulting, grabens with like orientation are considered to be a set and numbered. Sets numbered 1 are considered to have occurred first and are likewise, the oldest event of the given area.

Candor Mensa corresponds to the highest topographical area across the Valles Marineris region. Incidentally, this corresponds to the region of most faulting (Fig. 1, Area #1). In area #1 there are five sets of faults. All other areas contain only two sets, with the exception of one area where there are three sets. The region with three sets corresponds to the second-highest region topographically.

The topographical gradient of the Valles Marineris region trends northeast-southwest [4,5] with a central high located in Candor Mensa. At least one set of faults from each area is perpendicular to the trend, except for area #3 where the perpendicular set of faults is probably a result of local stresses. Gravitational influences may have promoted extentional deformation in the orientation perpendicular to downslope trend.

The western portion of the Valley is Late Hesperian in age, the central part, younger than Early Hesperian, and the easternmost and oldest part of the Valley is younger than Noachian in age. Level of faulting in these three regions can be correlated approximately with age. The greatest amount of faulting is in the westernmost and youngest end, and the least amount of faulting is in the easternmost, oldest end. There is a moderate amount of faulting in the center. The majority of deformation apparently has occurred relatively recently.

Characteristics of the faults (orientation, number of faults in a set, length) are assessed to determine whether deformation occurred as a result of a local or regional stress source. Most sets are believed to be a result of regional stress and trend either northwesterly or northeasterly. There are also two large (with many, long faults) sets that trend east-west. From cross-cutting relationships it is believed that the surficial, shallow grabens are a result of three extensional episodes. A northwesterly trending stress field occurred first (resulting in the perpendicular, northeasterly trending fault sets), then an northeasterly trending field created northwesterly trending faults, and lastly a north-south oriented stress field occurred (parallel to Valley trend). In addition to the regional stresses, it is likely that three local events also occurred, two south of Melas Chasma, and one north of Candor Chasma.

Conclusions: It is possible that, prior to the formation of Valles Marineris proper, two main tectonic events occurred that resulted in the northeasterly and northwesterly trending shallow plateau grabens. The last deformational episode could have created both the Valley and the east-west trending sets of plateau grabens. The conclusion that the Valley is a relatively young structure independently supports previous findings for regional-scale modeling for Tharsis.

References: [1] Banerdt et al., Stress and Tectonics on Mars, in *Mars*, Univ. of Arizona, 1992. [2] Tanaka et al., *JGR 96,* 15,617–15,633, 1991. [3] Mège and Masson, *Planet. Space Sci. 44,* 749–782, 1996. [4] Lucchitta et al., *JGR, 99,* 3783–3798, 1994. [5] Schultz, U.S.G.S. Miscellaneous Investigations Series Map I-2588 (MTM-10067), in press, 1996.

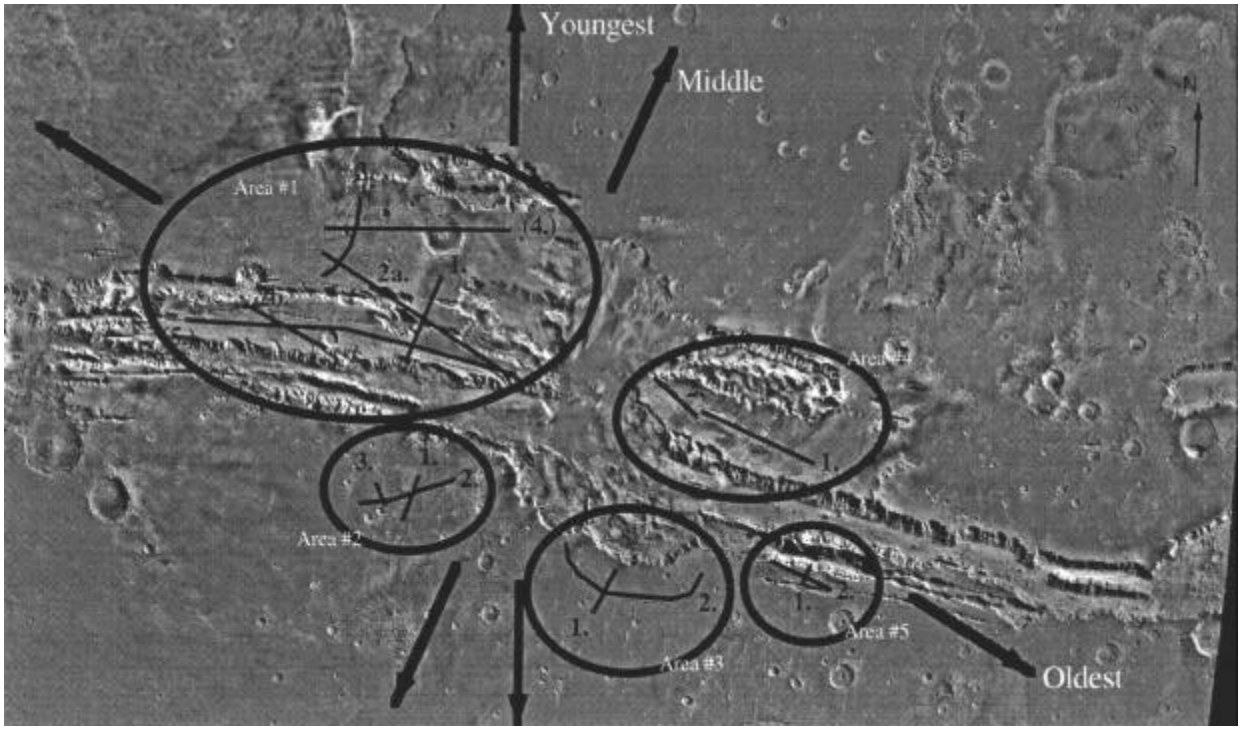

Fig. 1. Regional map of Valles Marineris showing delineated areas (grey circles), fault sets (thin black lines), and stress trajectories (heavy black arrows).